

WHAT IS CLAIMED IS

1. A stereolithographic apparatus for irradiating light to an unhardened photohardenable resin layer on the basis of data on stereolithography to optically form a desired three-dimensional object, characterized by comprising:

means for forming a mask on a light-transmissible member on the basis of stereolithographic data for one layer of photohardenable resin;

means for forming an unhardened resin layer of photohardenable resin;

means for disposing said light-transmissible member having said mask on the surface of said unhardened resin layer while said light-transmissible member is brought into close contact with said unhardened resin layer;

exposing means for exposing said unhardened resin layer to light through said mask to harden the photohardenable resin of said unhardened resin layer; and

evacuating means for evacuating said light-transmissible member from said hardened photohardenable resin layer after the photohardenable resin of said unhardened resin layer is exposed to light, the desired three-dimensional object being formed by repeating the stereolithography using said respective means.

2. A stereolithographic apparatus for irradiating light to an unhardened photohardenable resin layer on the basis of data on stereolithography to optically form a desired three-dimensional object, characterized by comprising:

means for forming a mask on a light-transmissible member on the basis of stereolithographic data for one layer of photohardenable resin; photohardenable resin supply/forming means for successively supplying photohardenable resin of one layer to form an unhardened resin layer of photohardenable resin;

a film having light transmission which is attached onto said unhardened resin layer so as to cover said unhardened resin layer in close contact with said unhardened resin layer;

means for disposing said light-transmissible member having said mask on said film while said light-transmissible member is brought into close contact with said film;

exposure means for exposing said unhardened resin layer to light through said mask to harden the photohardenable resin of said unhardened resin layer; and

evacuating means for evacuating said light-transmissible member and said film from said hardened photohardenable resin layer after the exposure by said exposure means, the desired three-dimensional object being formed by repeating the stereolithography using said respective means.

3. The stereolithographic apparatus as claimed in claim 2, wherein said photohardenable resin supply/forming means includes a resin supply dipper for stocking photohardenable resin and supplying photohardenable resin to form a layer of photohardenable resin, a coating blade for flattening the surface of the photohardenable resin layer thus formed, and a peeling/attaching roller for peeling said film off said hardened photohardenable resin layer and attaching said film to said hardened

photohardenable resin layer while being attached, said resin supply dipper, said coating blade and said peeling/attaching roller being integrated into one unit, and the formation/flattening of said unhardened resin layer and the peeling/attaching of said film being alternately carried out by reciprocating said unit.

4. The stereolithographic apparatus as claimed in claim 3, wherein said unit is disposed between a pair of rollers between which said film is attached.

5. The stereolithographic apparatus as claimed in claim 3, wherein an usable area of said film is varied in accordance with the degree of damages of said film.

6. The stereolithographic apparatus as claimed in claim 3, wherein said unit further includes means for peeling photohardenable resin attached to the back surface of said film.

7. The stereolithographic apparatus as claimed in claim 3, further comprising a tank for withdrawing surplus resin of resin supplied from said resin supply dipper.

8. The stereolithographic apparatus as claimed in claim 2, wherein said film is composed of synthetic resin such as polyester or the like.

9. The stereolithographic apparatus as claimed in claim 1, wherein said light-transmissible member comprises a glass plate.

10. The stereolithographic apparatus as claimed in claim 1, wherein said exposure means comprises an exposure device for plane-exposing photohardenable resin through said mask, and said exposure device has a hood which is descended to cover said light-transmissible member when the plane-exposure is carried out.

11. The stereolithographic apparatus as claimed in claim 10, wherein said exposure device further includes a light source and a fixed casing for accommodating said light source therein, and said hood has an upper end joined to said casing and a lower end which is downwardly moved so as to freely expand and contract in the form of bellows to cover said light-transmissible member.

12. The stereolithographic apparatus as claimed in claim 11, wherein said hood is suspended by a wire, and said wire is freely wound up by a motor.

13. The stereolithographic apparatus as claimed in claim 10, wherein said hood and said light-transmissible member are joined and positioned to each other when said hood is downwardly moved and covers said light-transmissible member.

14. The stereolithographic apparatus as claimed 10, further comprising a rail member which is upwardly urged by a spring member and supports said light-transmissible member so as to move said light-transmissible member freely upwardly and downwardly, and fixing means for linking said hood, said light-transmissible member and said rail member to one another when said hood is downwardly moved and covers said light-transmissible member, pushing said light-transmissible member and said rail member against the spring force of said spring member until said rail member abuts against a height positioning pin, and fixing said hood, said light-transmissible member and said rail member to the position at which said rail member abuts against said height positioning pin.

15. The stereolithographic apparatus as claimed in claim 14, further including a positioning pin which is fitted in a pin hole formed in said light-

transmissible member to suppress the rotation of said light-transmissible member on the horizontal plane when said hood, said light-transmissible member and said rail member are pushed down against the spring force of said spring member.

16. The stereolithographic apparatus as claimed in claim 15, wherein said positioning pin is disposed obliquely.

17. A stereolithographic apparatus for irradiating light to an unhardened photohardenable resin layer on the basis of stereolithographic data to harden the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

means for forming a mask on a light-transmissible member on the basis of stereolithographic data for one layer of photohardenable resin;

a stereolithographic table for mounting photohardenable resin thereon;

coating means for successively coating photohardenable resin on said table to form each unhardened photohardenable resin layer;

film attaching means for attaching a film having light transmission onto said unhardened photohardenable resin layer;

means for superposing said light-transmissible member having said mask on said film;

exposure means for exposing the photohardenable resin of said unhardened photohardenable resin layer through said mask; and

film peeling means for peeling said film after said unhardened photohardenable resin layer is exposed, the desired three-dimensional object

being formed by repeating the stereolithography using said respective means.

18. The stereolithographic apparatus as claimed in claim 17, wherein said stereolithographic table is controlled to be moved freely downwardly every time one layer of photohardenable resin is formed.

19. The stereolithographic apparatus as claimed in claim 18, wherein said stereolithography table is disposed substantially at the center of said stereolithographic apparatus, said exposure means is disposed at the upper portion of said stereolithographic apparatus, said coating means, said film attaching means and said film peeling means are disposed at one side of said stereolithographic apparatus and said mask forming means is disposed at the other side of said stereolithographic apparatus.

20. The stereolithographic apparatus as claimed in claim 18, further a servo motor for moving said stereolithographic table upwardly and downwardly.

21. The stereolithographic apparatus as claimed in claim 17, further including moving means which is disposed between said mask forming means and said stereolithographic table so as to be reciprocatively movable between said mask forming means and said stereolithographic table while said light-transmissible member is supported by said moving means.

22. The stereolithographic apparatus as claimed in claim 21, wherein said moving means comprises a rail member.

23. The stereolithographic apparatus as claimed in claim 22, wherein said rail member comprises a first rail at the mask forming means side and a second rail at the stereolithographic table side which are separated from and independent of each other.

24. The stereolithographic apparatus as claimed in claim 23, wherein said

first rail comprises two rails, and said light-transmissible member is pushed from one rail to the other rail to be positioned in the width direction thereof in the process that said light-transmissible member is guided by said two rails and said mask is formed on said light-transmissible member.

25. The stereolithographic apparatus as claimed in claim 21, wherein said moving means has a belt, and said light-transmissible member has on the lower surface thereof a projection which is to be hooked to said belt, said light-transmissible member being reciprocally moved between said mask forming means and said stereolithographic table by driving said belt.

26. The stereolithographic apparatus as claimed in claim 17, further including a light-transmissible member standby stage at one side of said mask forming means, wherein said light-transmissible member is reciprocally moved through said light-transmissible member standby stage, said mask forming means and said stereolithographic table in this order.

27. The stereolithographic apparatus as claimed in claim 26, wherein an operating lever is disposed over said light-transmissible member standby stage, said mask forming means and said stereolithographic table, stoppers are fixed to both the end portions of said operating lever, and said mask forming means is upwardly moved when said light-transmissible member abuts against one of said stoppers at the light-transmissible member standby stage side while said mask forming means is downwardly moved when said light-transmissible member abuts against the other stopper at the stereolithographic table side.

28. The stereolithographic apparatus as claimed in claim 17, wherein said light-transmissible member comprises a glass plate.

29. The stereolithographic apparatus as claimed in claim 28, wherein said mask forming means comprises charging means for charging said glass plate in accordance with stereolithographic data of one layer of photohardenable resin to form a latent image on said glass plate, and developing means for coating toner onto said glass plate having the latent image formed thereon to form a mask corresponding to the data of the one layer of photohardenable resin on said glass plate.

30. The stereolithographic apparatus as claimed in claim 29, wherein said mask forming means further includes a demagnetizing head for demagnetizing the surface of said glass plate, and a toner scraper for scraping surplus toner off said glass plate.

31. The stereolithographic apparatus as claimed in claim 30, wherein said mask forming means further includes a cover for covering said toner scraper, and a toner suction hose which is connected to said cover to suck toner.

32. The stereolithographic apparatus as claimed in claim 17, further including means for making parallel light incident to said light-transmissible member.

33. The stereolithographic apparatus as claimed in claim 32, wherein said means for making parallel light incident to said light-transmissible member comprises a grid provided between said exposure means and said light-transmissible member, and said exposure means irradiates light to the surface of said unhardened photohardenable resin layer at a time by using said grid.

34. The stereolithographic apparatus as claimed in claim 17, wherein said exposure means includes a cylindrical lens for forming parallel light, and said

exposure means is moved to expose the photohardenable resin to light.

35. The stereolithographic apparatus as claimed in claim 17, wherein said exposure means includes a light source, a fixed casing for accommodating said light source therein, and a hood having an upper end joined to said casing and a lower end which is downwardly moved so as to freely expand and contract in the form of bellows to cover said light-transmissible member, and said stereolithographic apparatus further includes means which is disposed on the lower surface of said hood and serves to make parallel light to said light-transmissible member.

36. The stereolithographic apparatus as claimed in claim 35, wherein said light source of said exposure means comprises a mercury lamp, a metal halide lamp or an ultraviolet fluorescent lamp.

37. The stereolithographic apparatus as claimed in claim 37, wherein said light source of said exposure means turns on at all times, and said stereolithographic apparatus further includes a shutter which is disposed between said exposure means and said light-transmissible member and serves to control light exposure/interception to said light-transmissible member.

38. The stereolithographic apparatus as claimed in claim 37, wherein said shutter comprises a light non-transmissible sheet having a light-transmissible opening portion, and the light exposure/interception to said light-transmissible member is controlled by moving said light non-transmissible sheet.

39. The stereolithographic apparatus as claimed in claim 37, wherein said shutter comprises a light non-transmissible plate, and the light

exposure/interception to said light-transmissible member is controlled by alternately changing the open/close direction of said shutter.

40. The stereolithographic apparatus as claimed in claim 40, wherein said film is composed of synthetic resin such as polyester or the like.

41. The stereolithographic apparatus as claimed in claim 17, wherein said light-transmissible member comprises a glass plate.

42. A stereolithographic apparatus for irradiating light to an unhardened photohardenable resin layer on the basis of data on stereolithography to optically form a desired three-dimensional object, characterized by comprising:

means for forming a mask on a light-transmissible member on the basis of stereolithographic data for one layer of photohardenable resin;

means for forming an unhardened resin layer of photohardenable resin;

means for disposing said light-transmissible member having said mask above said unhardened resin layer;

exposing means for exposing said unhardened resin layer to light through said mask to harden the photohardenable resin of said unhardened resin layer; and

evacuating means for evacuating said light-transmissible member from said hardened photohardenable resin layer after the photohardenable resin of said unhardened resin layer is exposed to light, the desired three-dimensional object being formed by repeating the stereolithography using said respective means.

44. A stereolithographic apparatus for irradiating light to an unhardened

photohardenable resin layer on the basis of stereolithographic data to harden the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

means for forming a mask on a light-transmissible member on the basis of stereolithographic data for one layer of photohardenable resin;

a stereolithographic table for mounting photohardenable resin thereon;

coating means for successively coating photohardenable resin on said table to form each unhardened photohardenable resin layer;

film attaching means for attaching a film having light transmission onto said unhardened photohardenable resin layer;

means for disposing said light-transmissible member having said mask above said film;

exposure means for exposing the photohardenable resin of said unhardened photohardenable resin layer through said mask; and

film peeling means for peeling said film after said unhardened photohardenable resin layer is exposed, the desired three-dimensional object being formed by repeating the stereolithography using said respective means

45. A stereolithographic method for irradiating light to an unhardened photohardenable resin layer on the basis of stereolithographic data to harden the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

a step of forming a mask on a light-transmissible member on

the basis of stereolithographic data of one layer of photohardenable resin;

a step of forming one unhardened photohardenable resin layer;

a step of disposing the light-transmissible member having the mask on the unhardened photohardenable resin layer while the light-transmissible member is brought into close contact with the unhardened photohardenable resin layer;

a step of exposing the unhardened photohardenable resin layer to light through the mask; and

a step of evacuating the light-transmissible member after the unhardened photohardenable resin layer is exposed to light, a series of said steps being repeated in this order to form a desired three-dimensional object.

46. A stereolithographic method for irradiating light to an unhardened photohardenable resin layer on the basis of stereolithographic data to harden the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

a step of forming a mask on a light-transmissible member on the basis of stereolithographic data of one layer of photohardenable resin;

a step of forming an unhardened photohardenable resin layer on a stereolithographic table;

a step of attaching onto the unhardened photohardenable resin layer a film having light transmission which holds the unhardened photohardenable resin layer;

a step of disposing the light-transmissible member having the

mask on the film while the light-transmissible member is brought into close contact with the film;

a step of exposing the unhardened photohardenable resin layer to light through the mask; and

a step of evacuating the light-transmissible member and the film after the unhardened photohardenable resin layer is exposed to light, a series of said steps being repeated in this order to form a desired three-dimensional object.

47. The stereolithographic method as claimed in claim 46, wherein there are provided a resin supply dipper for stocking photohardenable resin and supplying photohardenable resin to form a layer of photohardenable resin, a coating blade for flattening the surface of the photohardenable resin thus coated, and a peeling/attaching roller for peeling the film off said hardened photohardenable resin layer and attaching the film to said hardened photohardenable resin layer while being attached, the resin supply dipper, the coating blade and the peeling/attaching roller being integrated into one unit, and wherein when said unit is moved from one side of said stereolithographic apparatus to the other side thereof, an unhardened photohardenable resin layer is formed by the resin supply dipper while the film is peeled off by the film peeling/attaching roller, and when the unit is moved from the other side to the one side, the film is attached onto the unhardened photohardenable resin layer by the film peeling/attaching roller while the unhardened photohardenable resin layer is flattened by the coating blade.

48. A stereolithographic method for irradiating light to an unhardened photohardenable resin layer on the basis of stereolithographic data to harden

the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

- a step of forming a mask on a light-transmissible member on the basis of stereolithographic data of one layer of photohardenable resin;

- a step of forming one unhardened photohardenable resin layer;

- a step of disposing the light-transmissible member having the mask above the unhardened photohardenable resin layer;

- a step of exposing the unhardened photohardenable resin layer to light through the mask; and

- a step of evacuating the light-transmissible member after the unhardened photohardenable resin layer is exposed to light, a series of said steps being repeated in this order to form a desired three-dimensional object.

49. A stereolithographic method for irradiating light to an unhardened photohardenable resin layer on the basis of stereolithographic data to harden the photohardenable resin layer and repeating the light-irradiating operation on subsequent unhardened photohardenable resin layers in turn to optically form a desired three-dimensional object, characterized by comprising:

- a step of forming a mask on a light-transmissible member on the basis of stereolithographic data of one layer of photohardenable resin;

- a step of forming an unhardened photohardenable resin layer on a stereolithographic table;

- a step of attaching onto the unhardened photohardenable resin layer a film having light transmission which holds the unhardened

photohardenable resin layer;

a step of disposing the light-transmissible member having the mask above the film;

a step of exposing the unhardened photohardenable resin layer to light through the mask; and

a step of evacuating the light-transmissible member and the film after the unhardened photohardenable resin layer is exposed to light, a series of said steps being repeated in this order to form a desired three-dimensional object.

50. A stereolithographic method including a photohardened layer forming step of exposing a photohardenable resin composition layer to light controlled on the basis of stereolithographic data to harden the photohardenable resin composition layer, thereby forming a photohardened layer having predetermined pattern and thickness, and a photohardened layer forming/laminating step for forming a photohardenable resin composition layer on the photohardened layer formed in said photohardened layer forming step, exposing the photohardenable resin composition layer to light controlled on the basis of stereolithographic data to laminate a subsequent photohardened layer on the preceding photohardened layer, and repeating the lamination of a subsequent photohardened layer on a preceding photohardened layer until a desired three-dimensional object is obtained, characterized in that the photohardenable resin composition has a melting temperature ranging from 5 to 90°C when unhardened, and in at least a part of said photohardened layer forming/laminating process, under a state that an unhardened photohardenable resin layer forming the same surface as a

photohardened layer which has been already formed is kept solid at a temperature less than the melting temperature, a layer of photohardenable resin composition is formed on the surface of the solid photohardenable resin composition layer, and the photohardenable resin composition layer is exposed to light controlled on the basis of stereolithographic data to laminate a photohardened layer on the solid photohardenable resin composition layer.

51. The stereolithographic method as claimed in claim 50, wherein the photohardenable resin composition has a melting temperature ranging from 15 to 80°C.

52. The stereolithographic method as claimed in claim 50, further including a step of heating the three-dimensional object thus obtained up to a temperature above the melting temperature of the photohardenable resin composition to liquefy the solid photohardenable resin composition layer after said photohardened layer forming/laminating step is completed, and separating the liquefied unhardened photohardenable resin composition from the three-dimensional object to thereby obtain a desired three-dimensional object.

53. The stereolithographic method as claimed in claim 50, further including a step of dissolving the solid photohardenable resin composition layer with solvent after said photohardened layer forming/laminating step is completed, and separating the liquefied photohardenable resin composition from the three-dimensional object to thereby obtaining a desired three-dimensional object.

54. The stereolithographic method as claimed in claim 50, wherein when a layer of photohardenable resin composition is supplied onto the surface of a

mount table and/or a solid photohardenable resin composition layer forming the same surface as a photohardened layer which has been already formed and then exposed to light, any one of the following methods is used:

(a) a method of supplying a photohardenable resin composition in a liquid form, exposing the photohardenable resin composition to light under control to form a photohardened layer having predetermined pattern and thickness;

(b) a method of supplying a photohardenable resin composition in a liquid form, cooling the photohardenable resin composition to a temperature less than the melting temperature to solidify the photohardenable resin composition and then exposing the surface of the solid photohardenable resin composition to light under control to form a photohardened layer having predetermined pattern and thickness;

(c) a method of supplying a photohardenable resin composition in a solid state, heating the photohardenable resin composition up to a temperature above the melting temperature to liquefy the solid photohardenable resin composition, and then exposing the liquid surface of the liquefied photohardenable resin composition to light under control to form a photohardened layer having predetermined pattern and thickness; and

(d) a method of supplying a photohardenable resin composition in a solid state, and then exposing the surface of the solid photohardenable resin composition to light under control to form a photohardened layer having predetermined pattern and thickness.

55. The stereolithographic apparatus as claimed in claim 50, further comprising:

a first step of irradiating light under control to the surface of liquid photohardenable resin composition on a mount table to form a photohardened layer having predetermined pattern and thickness;

a second step of keeping a photohardenable resin composition layer forming the same surface as the photohardened layer formed in said first step at a temperature less than the melting temperature of the photohardenable resin composition to solidify the photohardenable resin composition layer;

a third step of supplying a layer of photohardenable resin composition in a liquid state on the solid photohardenable resin composition layer formed in said second step, and irradiating light under control to the surface of the liquid photohardenable resin composition layer to form a photohardened layer having predetermined pattern and thickness on the photohardened layer formed in said first step;

a fourth step of keeping a photohardenable resin composition resin layer forming the same surface as the photohardened layer formed in said third step at a temperature less than the melting temperature thereof to solidify the photohardenable resin composition resin layer; and

a fifth step of supplying a layer of photohardenable resin composition in a liquid state on the solid photohardenable resin composition resin layer formed in said fourth step and irradiating light under control to the surface of the liquid photohardenable resin composition layer to form and laminate a photohardened layer having predetermined pattern and thickness on the photohardened layer formed in said third step, said fourth step and said fifth step being repeated until a desired three-dimensional object is

formed.

56. The stereolithographic apparatus as claimed in claim 50, further comprising:

a first step of supplying photohardenable resin composition in a liquid state onto a mount table, and then cooling the photohardenable resin composition to a temperature less than the melting temperature thereof to solidify the photohardenable resin composition;

a second step of irradiating light under control to the surface of the photohardenable resin composition solidified in said first step to form a photohardened layer having predetermined pattern and thickness;

a third step of supplying a layer of photohardenable resin composition in a liquid state onto the solid photohardenable resin composition layer under cool after said second step;

a fourth step of cooling the photohardenable resin composition supplied in said third step to a temperature less than the melting temperature thereof to solidify the photohardenable resin composition; and

a fifth step of irradiating light under control to the surface of the photohardenable resin composition layer solidified in said fourth step to form a photohardened layer having predetermined pattern and thickness, said third step, said fourth step and said fifth step being repeated until a desired three-dimensional object is formed.

57. The stereolithographic apparatus as claimed in claim 50, further comprising:

a first step of supplying photohardenable resin composition in a solid state onto a mount table, heating the photohardenable resin

composition up to a temperature above the melting temperature thereof to liquefy the photohardenable resin composition, and then exposing light under control to the surface of the liquid photohardenable resin composition to form a photohardened layer having predetermined pattern and thickness;

a second step of keeping a photohardenable resin composition layer forming the same surface as the photohardened layer formed in said first step at a temperature less than the melting temperature thereof to solidify the photohardenable resin composition layer;

a third step of supplying a layer of photohardenable resin composition onto the solid photohardenable resin composition layer formed in said second step; and

a fourth step of heating the photohardenable resin composition layer supplied in said third step up to a temperature above the melting temperature thereof to liquefy the photohardenable resin composition layer, and then irradiating light under control to the liquid photohardenable resin composition layer to form a photohardened layer having predetermined pattern and thickness, said third step and said fourth step being repeated until a desired three-dimensional object is formed.

58. The stereolithographic apparatus as claimed in claim 50, further comprising:

a first step of supplying photohardenable resin composition in a solid state onto a mount table, and exposing light under control to the surface of the solid photohardenable resin composition to form a photohardened layer having predetermined pattern and thickness;

a second step of supplying a layer of solid photohardenable

resin composition while the photohardenable resin composition layer forming the same surface as the photohardened layer formed in said first step is kept solid at a temperature less than the melting temperature thereof; and

a third step of irradiating light under control to the surface of the solid photohardenable resin composition layer supplied in said second step to form a photohardened layer having predetermined pattern and thickness, said second step and said third step being repeated until a desired three-dimensional object is formed.

59. A stereolithographic apparatus comprising:

supply means of successively supplying a layer of photohardenable resin composition onto a mount table or a photohardened layer formed by hardening photohardenable resin composition;

stereolithography means having a light irradiation device for repeating formation/lamination of photohardened layers each having predetermined pattern and thickness under control until a desired three-dimensional object is formed; and

temperature adjusting means for setting the temperature of the photohardenable resin composition to a temperature less than the melting temperature thereof.

60. The stereolithographic apparatus as claimed in claim 59, wherein said temperature adjusting means is cooling means having control means for keeping, at a temperature less than the melting temperature of the photohardenable resin composition, a photohardenable resin composition layer forming the same surface as a photohardened layer which has been already formed, in the overall or a part of the stereolithographic process.

61. The stereolithographic apparatus as claimed in claim 59, further comprising heating means for heating unhardened photohardenable resin composition existing in an optical stereolithographic system up to a temperature above the melting temperature thereof at some midpoint of or after the end of the stereolithographic process.